5. Cold mass assembly

5.1 Yoking and skinning.

The following schematic represents the yoking assembly:

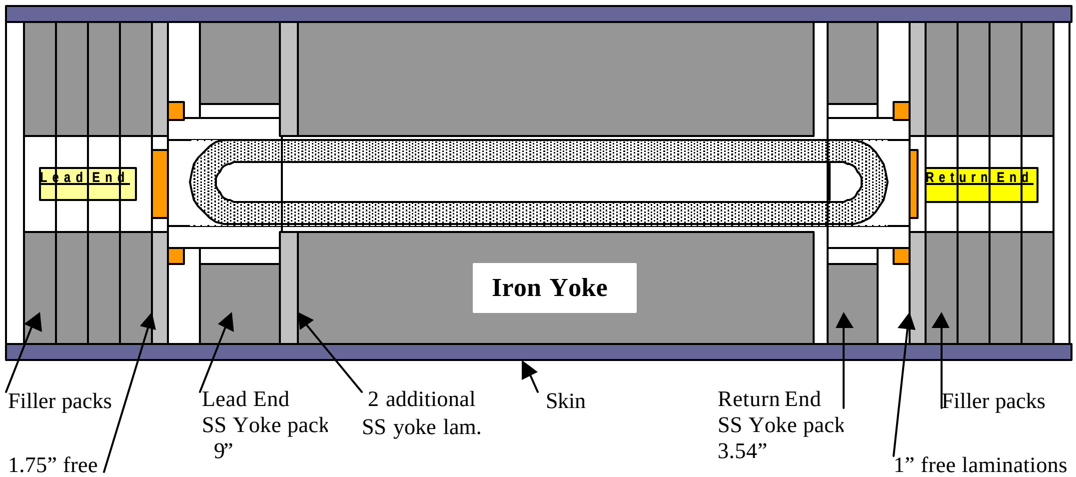

Figure 5.1. Yoke and skin layout.

All lamination packs were fusion welded longitudinally in 7 places (5 welds on outer surface and 2 welds on inner surface).

5.2 Tuning shims.

Tuning shims were bonded together using 5 min epoxy. The assembly was then tack welded into the yoke halves. Five tack welds were used, one in the middle, on both ends and one centered between the center and the ends. (See P0000486 at the web site, http://tspc01.fnal.gov/html/nobrega/HGQ05Yoke/.) One of the tack welds was broken on purpose because the tuning shim was bowed into the body of the yoke and would have interfered with the collar coil assembly insertion. The broken weld is in the second position from the near end on the far right side in figure P0000845A. When the weld was broken, the glue bond also failed and "super glue" was used to bond it back together. In the upper half of the yoke the parting plane welds at the ends were such that they’re existed a gap between the tuning shim and the yoke. Using a hammer on the brass shim the weld was smashed and the gap was eliminated between the shim and yoke. Picture P0000484 shows the lower yoke but the tack welds discussed above were on the other end and no picture is available.

We removed the ends of the lifting fixture, as it was too long to pick the collar coil assembly with the collets in place. The center portion of the lifting fixture was strong enough to lift the ~870 lbs. of the coil assembly. For reference, this configuration can NOT be used to lift a main body yoke pack. The collar assembly went into the lower yoke very nicely and with out any problems from the tuning shims or the yoke. This is primarily due to the straightness of the assembly. There was a clearance between the tuning shims and a single collar lamination on the order of 20-30 mils using uncalibrated eye. The upper half of the yoke was the easiest to install of all the model magnets to date. We moved the collared coil assembly to the center building after 8:30 (later than expected) and rolled the magnet into the press by 1:30.

5.3. Welding

The skin alignment key was 24 mm wide same as for HGQ-03. This leaves a gap of 1.75 mm between the yoke and the skin.The magnet was compressed at 600 Psi during welding. The magnet was compressed in the weld tooling with a hydraulic pressure of 600 PSI corresponded to force about 8000 lbs (3600 kg) per pusher or 16000 lbs/ft (23700 kg/meter) of magnet length. A pressure above 500 PSI must be applied to completely collapse the springs in the wheel units of the bottom tooling. The distance between the top and bottom pushers was measured from both the north and south side of the press all along the length of the magnet (see Fig. 5.2).

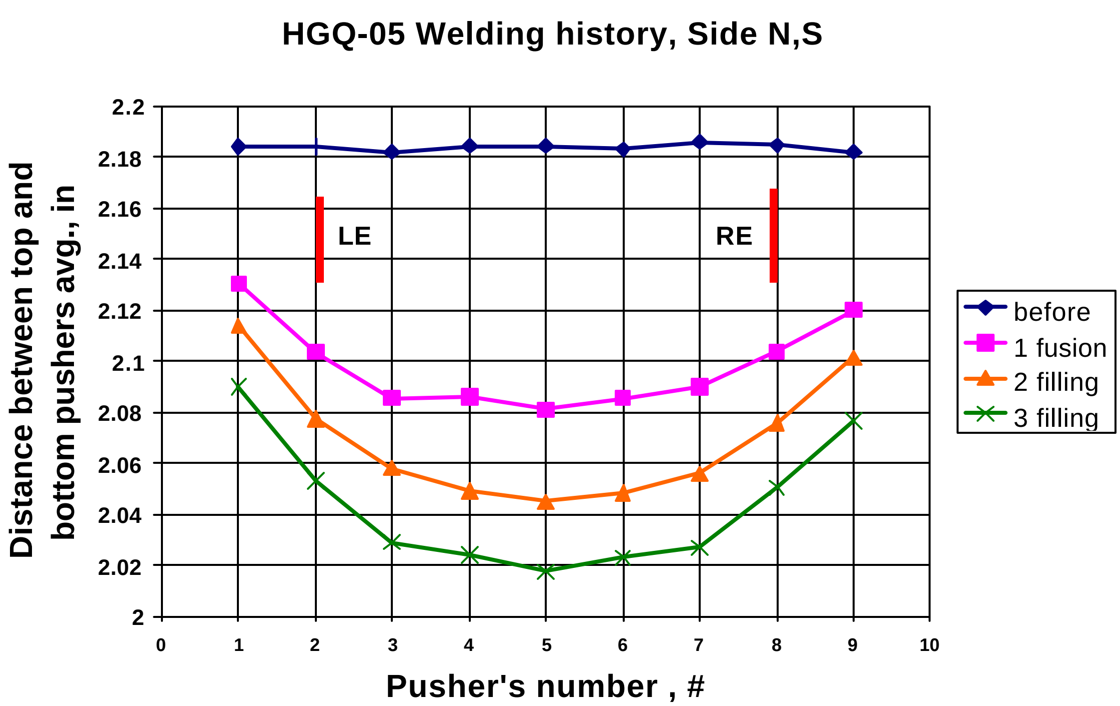

Fig. 5.2. Distance between top and bottom pushers.

The skin diameter measurements after welding are shown in Fig 5.2.

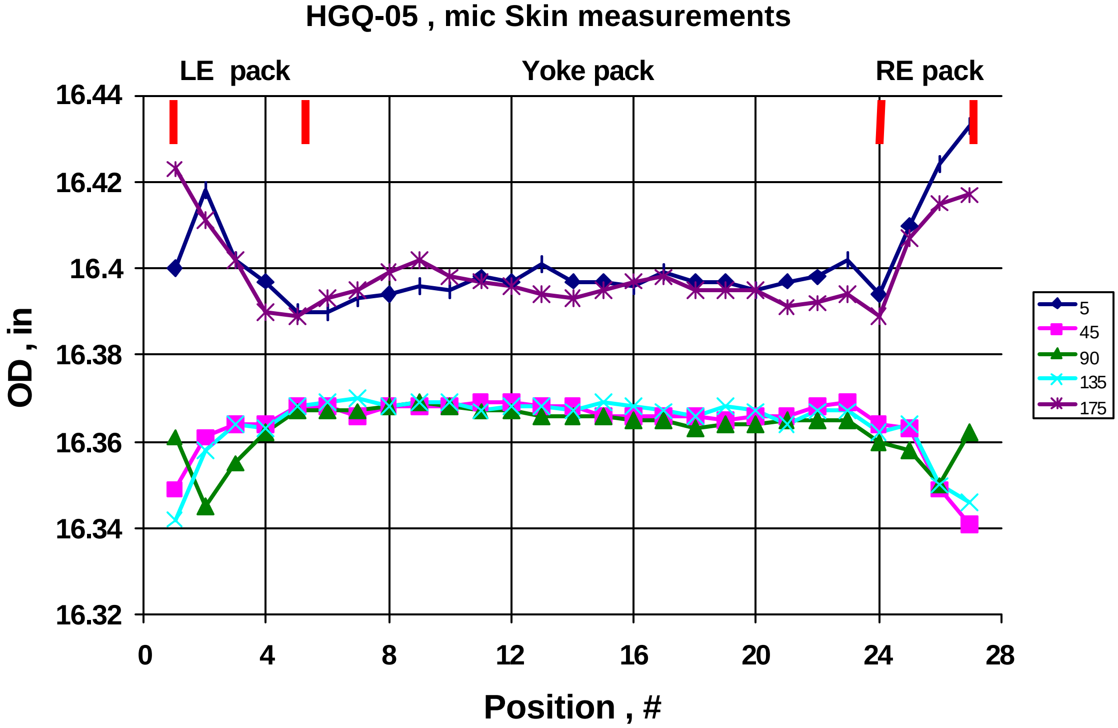

Fig.5.3. Skin outer diameter according to micrometer measurements taken at different angular positions between skin allayment keys.

Magnet lengths as design and as built shown on figures 5.4, 5.5.

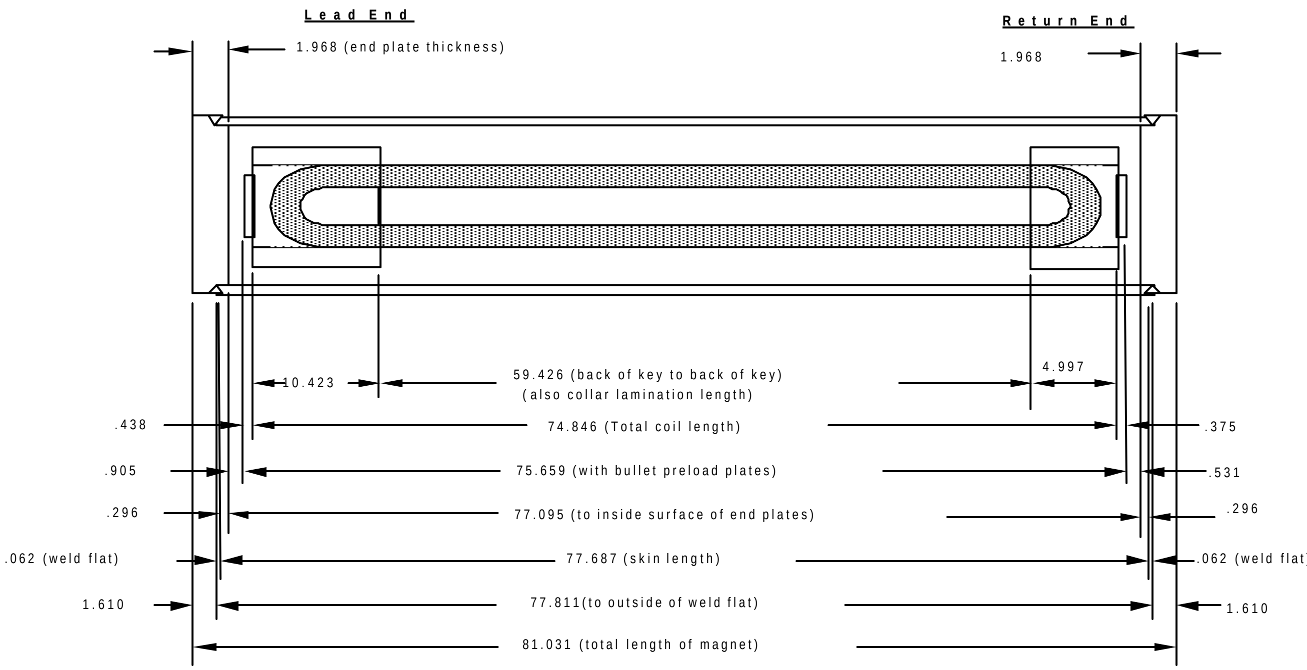

Figure 5.4. The design dimensions for HGQ05

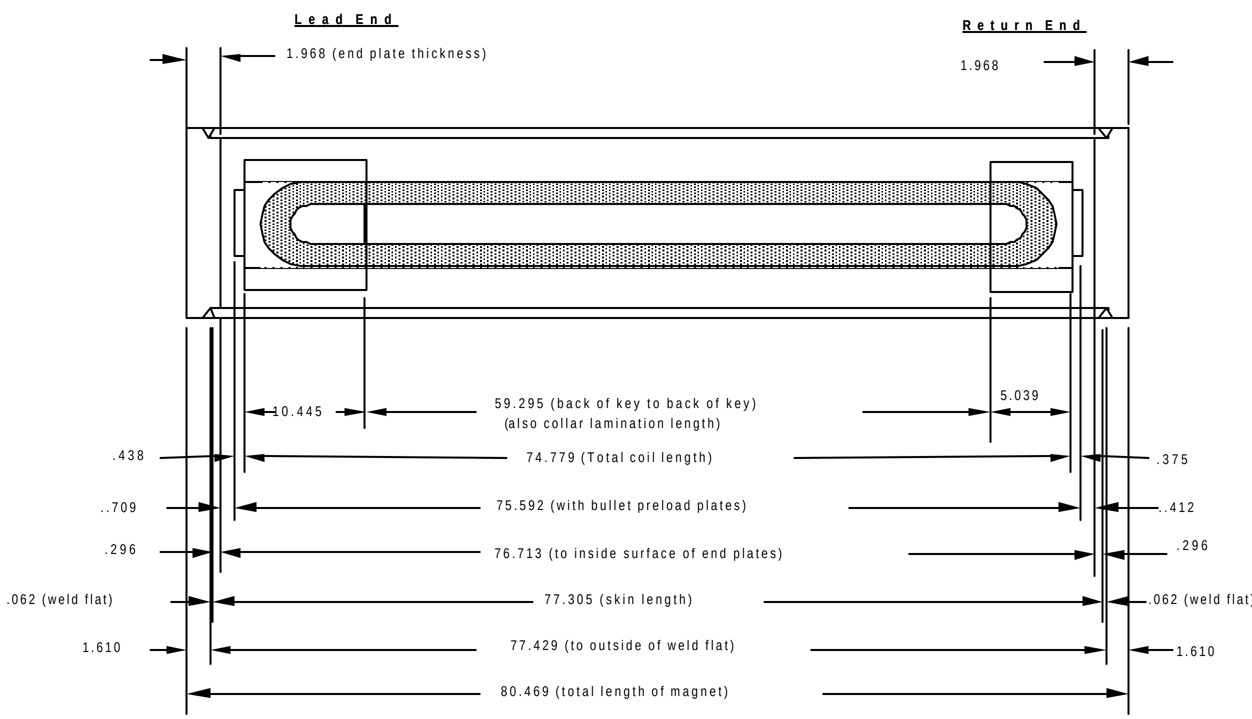

Figure 5.5. These are the measured dimensions for HGQ05

5.4. Bullet installation

The axial support system of the magnet shows below.

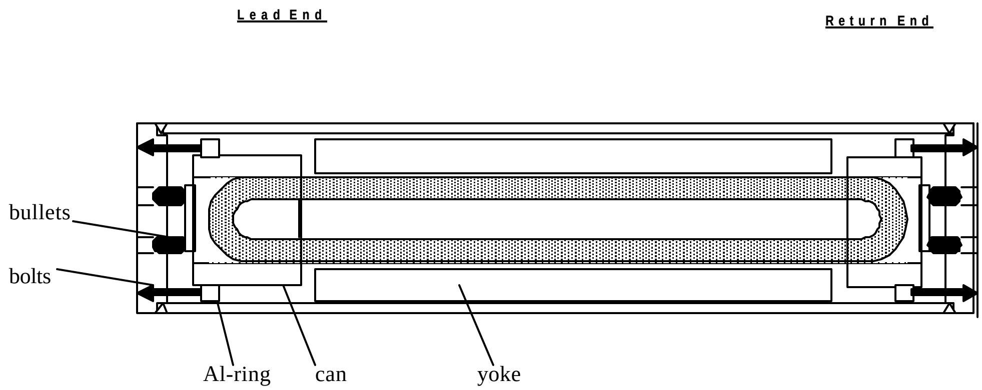

Figure 5.6. The axial support system of the magnet

The end load has been applied by snuggling the bullets to the solid pusher plate, then tightening the bolts. The gaps between coil end-saddles and pusher plat was filled by "green putty". The Lead End was loaded first. The bullet showed about 2400 lbs. At that time the Return End travel was -0.0055 in. The Return End bullets readied ~2000-2200 lbs. We toured RE bullets to achieved more or less equal force situation for both sides, ~2400 lbs. per bullet. Finally, the magnet stretched by total force ~18500 lbs. between two end plates. The magnet elongation was ~0.01 in.

Table 5.7. Bullet's reading.

Gauge ID	Type	Function	Quadrant	End	VMTF Name	IB#3 Data
						force, lbs
LHCBL27A	Bullet	Active	1	R	BuAcQ1aR	2222
LHCBL28A	Bullet	Active	2	R	BuAcQ2aR	2222
LHCBL31A	Bullet	Active	3	R	BuAcQ3aR	2273
LHCBL32A	Bullet	Active	4	R	BuAcQ4aR	2447
LHCBL33A	Bullet	Active	1	L	BuAcQ1aL	2316
LHCBL34A	Bullet	Active	2	L	BuAcQ2aL	2372
LHCBL35A	Bullet	Active	3	L	BuAcQ3aL	2485
LHCBL36A	Bullet	Active	4	L	BuAcQ4aL	2258

5.5. Twist

The twist in the cold-mass assembly after welding the skin was measured and found to be around 0.9 milliradian per meter in the straight section of the magnet. The twist in HGQ-01 was 4.67 milliradian per meter, for HGQ-02 it was 0.6 milliradian per meter, and for HGQ-03 it was 1.0 milli-radian per meter. The direction of the twist is same in all the three magnets and is clockwise looking from LE to RE.
Magnet twist shows on figure 5.8.

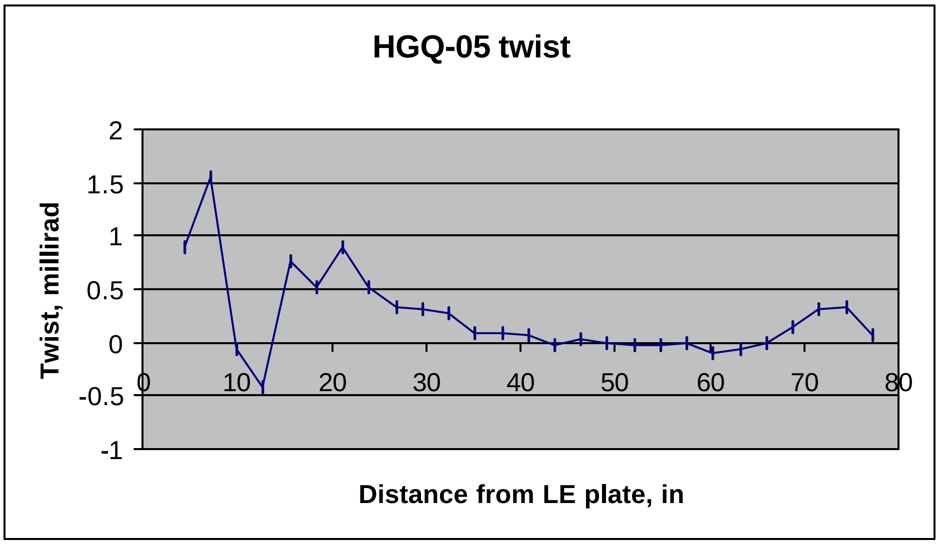

Figure 5.8. Magnet twist.

5.6. Skin gauges

The skin gauges location shown on figure 5.9. and table 5.10.

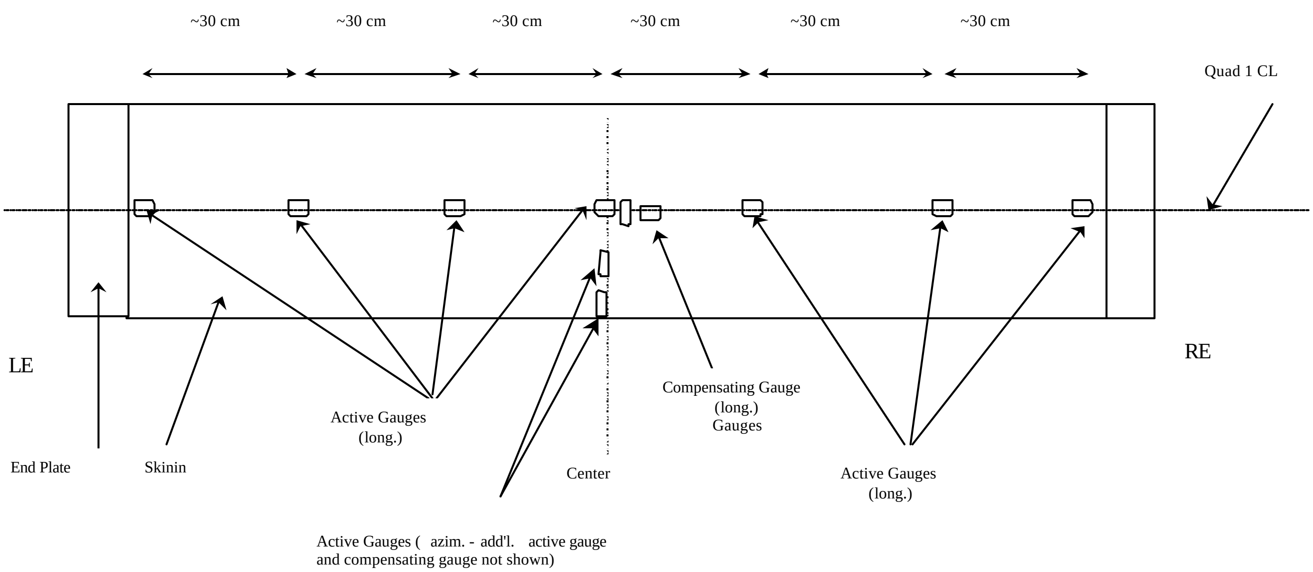

Figure 5.9. Skin gauge layout.

Table 5.10. Shell Gauge
List

Gauge ID	Type	Function	Dist from RE (cm.)	VMTF Name
HQSk#51	Longitudinal	Active	10	SkAcL010
HQSk#52	Longitudinal	Active	44	SkAcL044
HQSk#53	Longitudinal	Active	74	SkAcL074
HQSk#54	Longitudinal	Active	104	SkAcL104
HQSk#55	Longitudinal	Active	134	SkAcL134
HQSk#56	Longitudinal	Active	164	SkAcL164
HQSk#57	Longitudinal	Active	194	SkAcL190
HQSk#58	Azimuthal	Active	104, 0 degrees	SkAcA000
HQSk#59	Azimuthal	Active	104, 30 degrees	SkAcA030
HQSk#60	Azimuthal	Active	104, 60 degrees	SkAcA060
HQSk#61	Azimuthal	Active	104, ~90 degrees	SkAcA090
HQSk#37	Longitudinal	Comp	101, 0 degrees	SkCoL101
HQSk#38	Azimuthal	Comp	101, ~90 degrees	SkCoA090
HQSk#39	Azimuthal	Comp	101, 45 degrees	SkCoA045

5.7. Testing at IB3

HGQ-05 was hi-potted coil to ground, heater to ground and heater to coil at 1500 V. Leakage is required to be less than 0.5 μA at 1500 V.
The final electrical data collected before shipping to MTF:

	Resistance ohm	**Ls ■H**	**Q**
Q1 - inner	0.0830	179.973	2.04
Q1 - outer	0.1100	312.846	2.28
Q2 - inner	0.0811	179.662	2.03
Q2 - outer	0.1106	310.452	2.20
Q3 - inner	0.0825	179.055	2.10
Q3 - outer	0.1107	312.113	2.26
Q4 - inner	0.0838	179.895	2.07
Q4 - outer	0.1106	312.795	2.26
Q1 – Quadrant total	0.1904	812.223	3.61
Q2 – Quadrant total	0.1907	811.387	3.54
Q3 – Quadrant total	0.1901	810.790	3.52
Q4 – Quadrant total	0.1926	815.937	3.55
	Resistance ohm	**Ls MH**	**Q**
Magnet Total	0.7696	4.71095	4.48

Table 5.11: Magnet Resistance, L and Q measurements.

Heater	Resistance ohm	Heater	Resistance ohm
Q-1/2 – inner	7.150	Q-1/2 - outer	3.009
Q-2/3 – inner	7.164	Q-2/3 – outer	2.978
Q-3/4 - inner	7.112	Q-3/4 – outer	3.001
Q-4/1 - inner	7.161	Q-4/1 – outer	3.008

Table 5.12: Heater resistance measurements.